CATALOG DOCUMENTATION
EMAP-ESTUARIES PROGRAM LEVEL DATABASE
LOUISIANIAN PROVINCE 1991-1994
SEDIMENT TOXICITY DATA

TABLE OF CONTENTS

1. DATA SET IDENTIFICATION

1.1 Title

EMAP-Estuaries Province Level Database
Louisianian Province
Sediment Toxicity Data

1.2 Catalog Author

Virginia Engle, U.S. Environmental Protection Agency - NHEERL/GED
Linda Harwell, U.S. Environmental Protection Agency - NHEERL/GED
Tom Heitmuller, U.S. Geological Survey - BRD/GBPO

1.3 Catalog Revision Date

March 4, 1999

1.4 Data Set Name

TOXICITY

1.5 Task Group

ESTUARIES

1.6 Data set identification code

00044, 00084, 00124, 00164

1.7 Version number for a data set

001

1.8 Requested acknowledgment

If you plan to publish these data in any way, EPA requires a standard statement for work is has supported:

"Although the data described in this article have been funded wholly or in part by the U.S. Environmental Protection Agency through its EMAP Estuaries Program, it has not been subjected to Agency review, and therefore does not necessarily reflect the views of the Agency and no official endorsement should be inferred."

2. INVESTIGATOR INFORMATION

2.1 Principal Investigator

John M. Macauley
U.S. Environmental Protection Agency
NHEERL - GED

2.2 Sample Collection Investigator

John M. Macauley
U.S. Environmental Protection Agency
NHEERL - GED

2.3 Sample Processing Investigator

Tom Heitmuller
U.S. Geological Survey
BRD - GBPO

2.4 Data Analysis Investigator

Virginia D. Engle
U.S. Environmental Protection Agency
NHEERL - GED

2.5 Additional Investigators

N/A

3. DATA SET ABSTRACT

3.1 Abstract of the Data Set

The SEDIMENT TOXICITY TEST data file provides summary data on a sediment toxicity test associated with a station. The test was conducted using an homogenized sample composed of several grabs. Static ten-day sediment toxicity tests were conducted using the amphipod Ampelisca abdita (10-day exposure) and the mysid shrimp Mysidopsis bahia (96-hour exposure). The mean test sample survival as percent of the mean control survival is presented. A flag indicates if test mortality was significantly different from control mortality.

3.2 Keywords for the Data Set

Toxicity, Mortality, Survival

4. OBJECTIVES AND INTRODUCTION

4.1 Program Objective

The Environmental Monitoring and Assessment Program (EMAP) was designed to periodically estimate the status and trends of the Nation's ecological resources on a regional basis. EMAP provides a strategy to identify and bound the extent, magnitude and location of environmental degradation and improvement on a regional scale based on randomly located station sites. Only the randomly located Base Sampling Sites were included in this data set.

4.2 Data Set Objective

The primary objective of the sediment toxicity data file was to collect information relevant to the amphipod Ampelisca abdita and the mysid shrimp Mysidopsis bahia after exposure to sediment from a specific sampling location. The amphipod tests were 10-day exposures and the mysid tests were 96-hour exposures.

4.3 Data Set Background Information

Sediment toxicity tests were included in the EMAP design because the results of these tests have been used as indicators of environmental quality and ecological condition. The test is applicable to a variety of habitat types and biogeographical provinces, uses available methodology and produces results which can be interpreted. The test is categorized specifically as an Exposure Indicator because it is a biological measurement which can quantify pollutant exposure and degraded ecological condition.

The presence of contaminants in estuaries has been identified in both the scientific and popular press as a major problem contributing to degraded ecological resources and restricted harvest

of fish and shellfish resources due to human health concerns. Reducing contaminant inputs and concentrations, therefore, is often a major focus of regulatory programs for estuaries. Contaminants include both inorganic (primarily metals) and organic forms originating from many sources, including atmospheric deposition, freshwater inputs, land runoff and point sources. These sources are poorly characterized, except in the most well-studied estuaries. Most contaminants that are potentially toxic to indigenous biological resources tend to bind to particles, which ultimately are deposited at the bottom of estuaries. This binding changes the form of contaminants and removes them from the water column; consequently, contaminants accumulate in estuarine sediments.

Sediment toxicity tests are the most direct measure available for estimating the potential for contaminant-induced effects in benthic communities. These tests provide information that is independent of chemical characterizations and ecological surveys. They improve upon direct measures of contaminants because many chemicals are bound tightly to sediment particles or are complexed chemically, making them biologically unavailable. Mortality in these laboratory exposure tests can provide evidence of toxic contamination without requiring interpretation of how complex mixtures might interact to affect biota. However, sediment toxicity cannot be used entirely in replacement of direct measurement of sediment contaminant concentrations, since the latter is an important part of interpreting observed mortality in toxicity tests.

Although amphipod toxicity test methods have gained general acceptance, a number of factors that affect their application over the broad geographic and habitat range were assessed by EMAP - Estuaries. In addition, potential effects due to different holding times are also of concern. Processing samples may take as long as 30 days from the time of collection. The effects of holding time on results of sediment toxicity tests, however, have not been well-established.

4.4 Summary of Data Set Parameters

A summarization of replicate sediment toxicity test results compared to test control data is presented. Data were derived from two ten-day sediment toxicity tests using an amphipod and a mysid shrimp. Values were summarized over all replicates conducted with a sediment homogenate derived from several samples collected at a station.

4.5 Year-Specific Information about Data

None

5. METHODS

5.1 Data Acquisition

5.1.1 Sampling Objective

Collect one sediment sample per station suitable to conduct a sediment toxicity test with a marine organism. One (1) sediment sample was expected to be collected at each station.

5.1.2 Sample Collection Methods Summary

The grab sampler was attached to the end of a winch cable with a shackle and was cocked. The grab sampler was lowered through the water column such that travel through the last 5 meters is no faster than 1 m/sec. This minimized the effects of bow wave disturbance to surficial sediments. The grab penetrated the sediment by gravity releasing a trigger which kept the jaws of the grab open. When the grab was pulled from the sediment using the winch, the jaws closed, encapsulating the sediment sample. The sampler was retrieved and lowered into an on-board cradle.

Large, non-living surface items in the grab such as rocks or pieces of wood were removed from the sediment. The top two centimeters of the sediment at least one cm from the edge of the sample were removed using a stainless steel spoon (all utensils were cleaned with biodegradable labware soap and rinsed with ambient site water before use at each station). The sediment was placed in a pan or pot and placed in a cooler on ice for refrigerated storage. This procedure was repeated with each sediment grab collected until at least 4,300 cc of sediment had been collected. The sediment composite was then homogenized by stirring with a stainless steel spatula for 10 minutes. Using a stainless steel spatula, approximately 3,500 cc of the sediment homogenate was placed in a 4-liter Nalgene container for toxicity testing. The toxicity sample bottle was placed on ice.

5.1.3 Beginning Sampling Date

09 July 1991
08 July 1992
06 July 1993
06 July 1994

5.1.4 Ending Sampling Date

10 September 1991
11 September 1992
19 August 1993
15 September 1994

5.1.5 Sampling Platform

Each team was supplied with a 25-foot SeaArk work boat equipped with a 7.5 L gas engine fitted with a Bravo outdrive, an "A" frame boom assembly and hydraulic winch. On-board electronics consist of: a Loran C unit, GPS (beginning in 1993), radar unit, 2 VHF radios, cellular phone, compass, a depth finder, a tool kit, and all required and suggested safety equipment. One completely outfitted spare boat was stored at the Field Operations Center (EPA Lab) as backup.

5.1.6 Sampling Equipment

A 1/25 m2, stainless steel, Young-modified Van Veen Grab

sampler was used to collect sediments. This grab sampled an area of 413 cm2 and a maximum depth of penetration in the sediment of 10 cm.

5.1.7 Manufacturer of Sampling Equipment

5.1.8 Key Variables

5.1.9 Sampling Method Calibration

The sampling gear did not require any calibration. It required inspection for deformities incurred due to mishandling or impact on rocky substrates.

5.1.10 Sample Collection Quality Control

Prior to sampling at each station, the grab sampler was washed with biodegradable labware soap and thoroughly rinsed with ambient water at location to ensure that no sediment remained from a previous station.

A successful grab had relatively level, intact sediment over the entire area of the grab and a sediment depth at the center of > 7 centimeters. Unacceptable grabs included those: not containing any sediment, which were partially filled, had shelly substrates or grossly slumped surfaces or were completely filled to the top, where the sediment was in direct contact with the hinged top.
To minimize the chance of sampling the exact location twice, after three (3) grabs were taken, the boat was moved five (5) meters downstream by letting out the appropriate length of anchor line.

The spoon and processing (homogenizing) container used to process the sediment sample in the field were high grade stainless steel. The sample container was a four liter plastic jar.

5.1.11 Sample Collection Method References

Macauley, J.M. 1991. Environmental Monitoring and Assessment Program-Near Coastal Louisianian Province: 1991 Monitoring Demonstration. Field Operations Manual. EPA/600/X-91/XXX. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

Macauley, J.M. 1992. Environmental Monitoring and Assessment Program: Louisianian Province:1992 Sampling: Field Operations Manual. EPA/ERL-GB No. SR-119. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

Macauley, J.M. 1993. Environmental Monitoring and Assessment Program: Louisianian Province:1993 Sampling: Field Operations Manual. EPA/ERL-GB No. SR-XXX. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

Macauley, J.M. 1994. Environmental Monitoring and Assessment Program: Louisianian Province:1993 Sampling: Field Operations Manual. EPA/ERL-GB No. SR-XXX. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

5.2 Data Preparation and Sample Processing

5.2.1 Data Preparation Objective

Process uncontaminated sediment samples for characterization of sediment toxicity to the amphipod Ampelisca abdita and the mysid Mysidopsis bahia.

5.2.2 Data Processing Methods Summary

Sediment toxicity samples were stored in the dark at 4E C until used. The samples were tested within 30 days of collection.

Sediment for toxicity testing is taken from the same homogenate for the sediment chemistry sample; the homogenate consists of the top 2-cm layer taken from multiple grabs at each stations. Contamination was avoided in obtaining the sediment toxicity sample through strict adherence to protocol during sample collection.

All parameters such as water temperature, salinity (conductivity), dissolved oxygen, and pH were checked as required for each test and maintained within specified limits. The minimum requirement for acceptable overlying water was that it allows acceptable control survival without signs of organism disease or apparent stress. The overlying water used in sediment toxicity tests with Ampelisca tests had a salinity value of 30 while that used with mysids, 20 . Overlying water could be either natural uncontaminated seawater or artificially made seawater.

Instruments used for routine measurements were calibrated and standardized according to instrument manufacturer's procedures.

Control treatments used the same water, conditions, procedures, and organisms as the other test treatments, except that none of the test material was added to the control sediment or water. The control treatments were used to provide: a) a measure of the acceptability of the test by providing evidence of the health and relative quality of the test organisms, and the suitability of the overlying water, test conditions, and handling procedures, etc.; and b) the basis for interpreting data obtained from the test sediments. Mortality and sublethal effects such as emergence from the sediment were determined during and after exposure to the test sediment. Dead animals were counted and removed daily. At the end of the exposure time period relevant to each species, the test sediments were rinsed through a 0.5 mm mesh sieve. The material retained on the sieve was either examined that

day or preserved in 5% buffered formalin with Rose Bengal stain for later examination. Any amphipods which were not accounted for when the sieved material was examined were presumed to have died during the test. Survival in control treatments of <85% resulted in the entire test being repeated, discarded, or flagged.

5.2.3 Sampling Processing Method Calibration

N/A

5.2.4 Sample Processing Quality Control

Quality control objectives were necessary for each phase of a sediment toxicity test. All test organisms used in a test were disease-free and positively identified to species. Test organisms obtained from an outside source, were evaluated for sensitivity with a reference toxicant in a short-term toxicity test performed concurrently with the sediment toxicity tests. Laboratory and bioassay temperature control equipment were adequate to maintain recommended test temperatures. Recommended materials were used in the fabrication of the test equipment in contact with the water or sediment being tested. Parameters such as water temperature, salinity, dissolved oxygen, alkalinity, water hardness and pH should be checked as required for each test and maintained within specified limits. The minimum requirement for acceptable dilution of overlying water was that it allowed acceptable control survival without signs of organism disease or apparent stress.

The tests with Ampelisca abdita and Mysidopsis bahia were acceptable if mean control survival was greater than or equal to 85 percent, and if survival in individual control test replicates exceeded 80 percent. An individual test may be conditionally acceptable if temperature, dissolved oxygen or other specified conditions fall outside specifications, depending on the degree of the departure and the objectives of the tests. Any deviations from test specifications must be noted and reported to the QA officer when reporting the data so that a determination can be made of test acceptability. Data for all QA/QC variables, such as reference toxicant test results and copies of control charts, should be submitted by the laboratory along with test results.

5.2.5 Sampling Processing Method Reference

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual - Estuaries, Volume 1: Biological and Physical Analyses. United States Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008.

5.2.6 Sample Processing Method Deviations

None

6. DATA MANIPULATIONS

6.1 Name of New or Modified Values

SURVIVAL
SIG_CONT

6.2 Data Manipulation Description

The values under SURVIVAL represent a comparison of the mean test survival to the mean control survival.

A one-tailed t-test represents a comparison of the mean per cent sample mortality to the mean per cent control mortality.

6.3 Data Manipulation Examples

SURVIVAL = (Mean % Test Survival / Mean % Control Survival) * 100

SIG_CONT represents the results of a one-tailed t-test (alpha=0.05) used to determine if the mean per cent sample mortality was significantly different from the mean per cent control mortality.

6.4 Data Manipulation Computer Code File

6.5 Data Manipulation Computer Code Language

6.6 Data Manipulation Computer Code

7. DESCRIPTION OF PARAMETERS

7.1 Description of Parameters

7.1.1 Parameter Name

Field Name	Data Type	Max Field Len	Variable Format	Field Label
STA_NAME	Char	8	$8.	The Station Identifier
VST_DATE	Num	8	YYMMDD6.	The Date the Sample was Collected
SPECCODE	Char	8	$8.	EMAP Taxon Code
SURVIVAL	Num	8	5.1	% Survival (Samp Mean as % of Control)
SIG_CONT	Char	8	$3.	Sig Diff from Control(Samp x % Mortal'y)

7.1.6 Precision to which values are reported

Values are reported to one decimal point.

7.1.7 Accuracy of the data values

7.1.8 Minimum Value in Data Set

1991
1992
1993
1994

SURVIVAL
0
0
0
4.0

7.1.9 Maximum Value in Data Set

1991
1992
1993
1994

SURVIVAL
116.9
111.1
111.1
111.1

7.2 Data Record Example

7.2.1 Column Names for Example Records

STA_NAME VST_DATE SPECCODE SURVIVAL SIG_CONT

7.2.2 Example Data Records

STA_NAME	VST_DATE	SPECCODE	SURVIVAL	SIG_CONT
LA91LR01	910721	AMPEABDI	84.4	Y
LA91LR01	910721	MYSIBAHI	100.0	N
LA91LR02	910721	AMPEABDI	84.4	Y
LA91LR02	910721	MYSIBAHI	97.0	N
LA91LR03	910722	AMPEABDI	99.0	N

7.3 Related Data Sets

7.3.1 Related Data Set Name

7.3.2 Related Data Set Identification Code

8. GEOGRAPHIC AND SPATIAL INFORMATION

8.1 Minimum Longitude

-97 Degrees 27 Minutes 13.20 Decimal Seconds

8.2 Maximum Longitude

-82 Degrees 39 Minutes 28.20 Decimal Seconds

8.3 Maximum Latitude

30 Degrees 48 Minutes 30.00 Decimal Seconds

8.4 Minimum Latitude

26 Degrees 02 Minutes 55.80 Decimal Seconds

8.5 Name of the area or region

Louisianian Province - Coastal distribution of sampling is along the Gulf of Mexico from the Rio Grande, TX to Anclote Key, FL. States represented: Texas, Louisiana, Alabama, Mississippi, Florida

8.6 Direct Spatial Reference Method

Point

8.7 Horizontal Coordinate System Used

Universal Transverse Mercator

8.8 Resolution of Horizontal Coordinates

0.5

8.9 Units for Horizontal Coordinates

Meters

8.10 Vertical Coordinate System

N/A

8.11 Resolution of Vertical Coordinates

N/A

8.12 Units for Vertical Coordinates

N/A

9. QUALITY CONTROL AND QUALITY ASSURANCE

9.1 Measurement Quality Objectives

Measurement quality objectives were outlined in the Quality Assurance Project Plan. Accuracy and precision goals are outlined below:

Sediment Toxicity Tests	Accuracy Goal	Completeness Goal
Toxicity Tests	NA	100 %

9.1.1 Sample Processing Method Calibration

N/A

9.1.2 Sample Processing Quality Control

Quality control objectives were necessary for each phase of a sediment toxicity test. All test organisms used in a test were disease-free and positively identified to species. Test organisms obtained from an outside source, were evaluated for sensitivity with a reference toxicant in a short-term toxicity test performed concurrently with the sediment toxicity tests. Laboratory and bioassay temperature control equipment were adequate to maintain recommended test temperatures. Recommended materials were used in the fabrication of the test equipment in contact with the water or sediment being tested. Parameters such as water temperature, salinity, dissolved oxygen, alkalinity, water hardness and pH should be checked as required for each test and maintained within specified limits. The minimum requirement for acceptable dilution of overlying water was that it allowed acceptable control survival without signs of organism disease or apparent stress.

The tests with Ampelisca abdita and Mysidopsis bahia were acceptable if mean control survival was greater than or equal to 85 percent, and if survival in individual control test replicates exceeded 80 percent. An individual test may be conditionally acceptable if temperature, dissolved oxygen or other specified conditions fall outside specifications, depending on the degree of the departure and the objectives of the tests. Any deviations from test specifications must be noted and reported to the QA officer when reporting the data so that a determination can be made of test acceptability. Data for all QA/QC variables, such as reference toxicant test results and copies of control charts, should be submitted by the laboratory along with test results.

9.2 Quality Assurance/Control Methods

QA/QC procedures for sediment toxicity tests involved sample handling and storage, source and condition of test organisms, condition of facilities and equipment, test conditions, instrument calibration, replication, use of reference toxicants, record keeping, and data evaluation. Samples were chilled to four degrees Centigrade when collected, shipped on ice, and stored in the dark in a refrigerator at four degrees Centigrade for no longer than 30 days until used. All organisms used in the tests were disease-free and were positively identified to species. Organisms collected from the field prior to testing were obtained from an area known to be free of toxicants and were held in clean, uncontaminated water and facilities. If greater than five percent of the organisms in holding containers were dead or appeared unhealthy during the 48 hours preceding a test, the entire group was discarded.

The sensitivity of A. abdita collected from the field was evaluated with a 96-hour reference toxicant test (sodium dodecyl sulfate (SDS)) without sediment performed concurrently with each sediment

toxicity test. A control chart was prepared for each species and successive toxicity values were plotted and examined to determine if the results were within prescribed limits. In this technique, a running plot was maintained for the toxicity values from successive tests with a given reference toxicant. For regression analysis results (such as LC50s or IC50s), the mean and upper and lower control limits (+-2S) were recalculated with each successive point until the statistics stabilized. Values which fell outside the upper and lower control limits and trends of increasing or decreasing sensitivity could be readily identified. At the P=0.05 probability level, one in twenty tests would be expected to fall outside of the control limits by chance alone. If the toxicity value from a given test with the reference toxicant did not fall in the expected range for the test organisms, the sensitivity of the organisms and the overall credibility of the test would be suspect. In this case, the test procedure would have been examined for defects and, if possible, the test would have been repeated with a different batch of test organisms.

Facilities, water, control sediment, and handling techniques were adequate to result in acceptable control survival. Parameters such as water temperature, salinity, dissolved oxygen, and pH were checked as required for each test and maintained within the specified limits. Instruments used for routine measurements were calibrated and standardized according to instrument manufacturer's procedures. The natural seawater used as overlying water during toxicity tests was obtained from an uncontaminated area known to support a healthy, reproducing population of the test organism or a comparably sensitive species.

Bound notebooks were used to maintain detailed records of the test organisms such as species, source, age, date of collection, and other pertinent information relating to their history and health. These notebooks also contained information on the calibration of equipment and instruments, test conditions employed and test results. Annotations were made on a real-time basis to prevent loss of information.

A 10-day sediment toxicity test was considered unacceptable if one or more of the following occurred:

1. All test chambers were not identical.
2. Treatments were not randomly assigned to test chambers.
3. Test organisms were not randomly or impartially distributed to test chambers.
4. Required control treatments were not included in the test.
5. All test animals were not from the same population, were not all of the same species, or were not an acceptable quality.
6. Amphipods from a wild population were maintained in the laboratory for more than two weeks, unless the effects of prolonged maintenance in the laboratory has been shown to have no significant effect on sensitivity.
7. The test organisms were not acclimated at the test temperature and salinity at least 48 h before they were placed in the test chambers.
8. Temperature, dissolved oxygen, and concentration of test material were not measured, or were not within the ranges

specified:

Temperature: 20oC+-3oC for individual readings, 20oC+-1oC time-weighted average temperature at the end of the test, no more than 2oC difference among chambers measured concurrently.

Salinity: 30 ppt.

Dissolved Oxygen: DO concentration was maintained at >90% saturation, should never have dropped below 60% saturation.

9. Aeration to the test chambers was off for an extended time such that dissolved oxygen levels dropped to less than 60 % of saturation.

10. Response criteria were not monitored in a "blind" fashion, i.e., observers had knowledge of the treatment of sediments in the test chambers.

11. Mean percent survival of organisms in control treatments was less than 85% or survival in an individual control test chamber was less than 80%.

9.3 Actual Measurement Quality

The laboratory processing of the sediment toxicity tests for 1991-1993 EMAP-Estuaries Monitoring in the Louisianian Province fully met the prescribed QA/QC guidelines and all test results are included in the data file.

9.4 Sources of Error

9.5 Known Problems with the Data

9.6 Confidence Level/Accuracy Judgement

9.7 Allowable Minimum Values

9.8 Allowable Maximum Values

9.9 QA Reference Data

10. DATA ACCESS

10.1 Data Access Procedures

A Data Request Package can be requested from a contact under Section 7.3. Data can be downloaded from the WWW site.

10.2 Data Access Restrictions

Data can only be accessed from the WWW site.

10.3 Data Access Contact Persons

Dr. J. Kevin Summers
Technical Director, EMAP-Estuaries
U.S. Environmental Protection Agency
National Health and Environmental Effects Lab
Gulf Ecology Division
1 Sabine Island Dr.
Gulf Breeze, FL 32561
(904) 934-9244
(904) 934-9201 (FAX)
summers.kevin@epa.gov (E-MAIL)

John M. Macauley
Province Manager, EMAP-E Louisianian Province
U.S. Environmental Protection Agency
National Health and Environmental Effects Lab
Gulf Ecology Division
1 Sabine Island Dr.
Gulf Breeze, FL 32561
(904) 934-9353
(904) 934-9201 (FAX)
macauley.john@epa.gov (E-MAIL)

10.4 Data Set Format

Data can be transmitted in a variety of formats derived from SAS data files when a Data Request Form is submitted.

10.5 Information Concerning Anonymous FTP

Not accessible

10.6 Information Concerning World Wide Web

Data can be downloaded from the WWW

10.7 EMAP CD-ROM Containing the Data set

Data not available on CD-ROM.

11. REFERENCES

11.1 EMAP References

Heitmuller, P.T. and R. Valente. 1991. Environmental Monitoring and Assessment Program: EMAP-Estuaries Louisianian Province: 1991 quality assurance project plan. EPA/ERL-GB No. SR-120. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

Macauley, J.M. 1991. Environmental Monitoring and Assessment Program-Near Coastal Louisianian Province: 1991 Monitoring Demonstration. Field Operations Manual. EPA/600/X-91/XXX. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

Macauley, J.M. and J.K. Summers. 1991. Environmental Monitoring and Assessment Program, Near Coastal - Louisianian Province: 1991 Field Reconnaissance Report - East Region. EPA/600/04-91/XXX. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

Macauley, J.M. and J.K. Summers. 1991. Environmental Monitoring and Assessment Program, Near Coastal - Louisianian Province: Field Training Manual - Crew Chiefs. EPA/600/05-91/XXX. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

Macauley, J.M. and J.K. Summers. 1991. Environmental Monitoring and Assessment Program, Near Coastal - Louisianian Province: Field Training Manual - Crews. EPA/600/05-91/XXX. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561.

Summers, J.K., J.M. Macauley and P.T. Heitmuller. 1991. Environmental Monitoring and Assessment Program. Implementation Plan for Monitoring the Estuarine Waters of the Louisianian Province - 1991 Demonstration. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561. EPA/600/5-91/228.

Summers, J.K., J.M. Macauley, J.M., P.T. Heitmuller, V.D. Engle, A.M. Adams and G.T. Brooks. 1992. Annual Statistical Summary: EMAP-Estuaries Louisianian Province - 1991. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32561. EPA/600/R-93/001.

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual - Estuaries, Volume 1: Biological and Physical Analyses. United States Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008.

11.2 Background References

Engle, V.D., J.K. Summers, G.R. Gaston. 1994. A Benthic Index of Environmental Condition of Gulf of Mexico Estuaries. Estuaries. 17:372-384.

Summers, J. Kevin, John F. Paul, Andrew Robertson. 1995. Monitoring The Ecological Condition Of Estuaries In The United States. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL 32651.

12. GLOSSARY AND TABLE OF ACRONYMS

12.1 Acronym used in the Detailed Documentation

12.2 Definition of Acronym

13. PERSONNEL INFORMATION

Louisianian Province Manager
John M. Macauley
U.S. EPA NHEERL-GED
1 Sabine Island Dr.
Gulf Breeze, FL 32561
(904) 934-9353 (Tel.)
(904) 934-9201 (FAX)
macauley.john@epa.gov

EMAP-Estuaries Quality Assurance Coordinator
P. Thomas Heitmuller
U.S.G.S. - BRD
Gulf Breeze Project Office
1 Sabine Island Dr.
Gulf Breeze, FL 32561
(904) 934-9373 (Tel.)
(904) 934-2495 (FAX)
heitmuller.tom@epa.gov

EMAP-Estuaries Data Analyst
Virginia D. Engle
U.S. EPA NHEERL-GED
Gulf Breeze Project Office
1 Sabine Island Dr.
Gulf Breeze, FL 32561
(904) 934-9354 (Tel.)
(904) 934-9201 (FAX)
engle.virginia@epa.gov